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ORIGINAL ARTICLE *Reproductive epidemiology*

Sleep disturbances in a community-based sample of women with polycystic ovary syndrome

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STUDY QUESTION: Is there an excess of sleep disturbances in women with polycystic ovary syndrome (PCOS) in a community-based sample?

STUDY ANSWER: Sleep disturbances are almost twice as common in women with PCOS compared with women of similar age without PCOS, with the association slightly accounted for by body weight and, to a greater extent, by depressive symptoms.

WHAT IS KNOWN ALREADY: There is an excess of sleep-disordered breathing in clinical samples of women with PCOS, after accounting for their profile of body weight. Poor sleep patterns increase insulin resistance and thus may exacerbate PCOS symptoms and longer-term risk of metabolic disease.

STUDY DESIGN, SIZE, DURATION: A cross-sectional study of 724 women, comprising 74% of a cohort study established retrospectively when women were around age 30 years.

PARTICIPANTS/MATERIALS, SETTING, METHODS: Comparisons were made between 87 women with PCOS, diagnosed using the Rotterdam criteria, and 637 women without this diagnosis in Adelaide, South Australia. Differences in sleep disturbances, assessed using a modified version of the Jenkins questionnaire, were investigated using ordered logistic regression.

MAIN RESULTS AND THE ROLE OF CHANCE: Sleep disturbances were twice as common in women with PCOS compared with those without. Specifically, PCOS was associated with increasing occurrence of difficulty falling asleep (odds ratio (OR) 1.94, 95% confidence interval (CI) 1.28–2.95); this association was attenuated but still statistically significant after accounting for BMI and depressive symptoms. Increasing occurrence of difficulty maintaining sleep (OR 1.92 95% CI 1.12–3.31) was mediated by obesity and depressive symptoms, together. Other factors did not change these findings.

LIMITATIONS, REASONS FOR CAUTION: The cross-sectional nature of the study means that the direction of associations between PCOS and sleep disturbances is unclear, although bi-directionality for the mediators is likely based on data in the wider literature.

WIDER IMPLICATIONS OF THE FINDINGS: Our results indicate that assessment and management of both sleep and mental health problems in women with PCOS should be undertaken. Longitudinal data would be valuable to see how poor sleep affects longer-term health profiles.

STUDY FUNDING/COMPETING INTEREST(S): All funding for this study was from Australian academic and government sources. The authors have no competing interests to declare.

Key words: polycystic ovary syndrome / sleep disturbances / depression / obesity

Introduction

Polycystic ovary syndrome (PCOS) affects 9–18% of women of childbearing age (March *et al.*, 2010). Clinical features that are common, but variable, include menstrual irregularity, hyperandrogenism (that may manifest as hirsutism) and ovarian cysts; ensuing fertility problems are also widespread. Insulin resistance is a key aetiological feature of PCOS, present even in lean women with the syndrome (Dunaif and

Finegood, 1996), and in the longer-term women with PCOS have an increased risk of early onset type 2 diabetes (Moran *et al.*, 2010).

Tasali *et al.* have argued that obstructive sleep apnoea (OSA) in women with PCOS exacerbates insulin resistance and contributes to the development of type 2 diabetes (Tasali *et al.*, 2008). Since sleep fragmentation, rather than hypoxia, predicted insulin resistance in that study, other forms of sleep disturbance are potentially implicated in this pathway. This accords with long-standing conjecture about the metabolic consequences of sleep disturbances (Spiegel *et al.*, 2005) affirmed by epidemiological evidence (Cappuccio *et al.*, 2010) and recent experimental studies in which recurrent nights of insufficient sleep reduced insulin sensitivity, without compensatory insulin release, in healthy adults (Nedeltcheva *et al.*, 2009; Van Cauter, 2011).

Recognized sleep disturbances include insufficient sleep and the features of insomnia (difficulty falling asleep, or difficulty maintaining sleep, or waking up too early, or unrefreshing sleep), which can be problems for individuals even below the clinically defined duration of 1 month. Hallmark sequelae include daytime fatigue, sleepiness and irritability. These disturbances can occur in the absence of OSA (in which breathing is disordered during sleep). Of note, women's subjective experiences of sleep disturbances differ from that of men, with insomnia and subsequent low mood more characteristic than the snoring, apnoea and daytime sleepiness typical in men (Redline *et al.*, 1994; Pillar and Lavie, 1998).

Clinic-based samples of women with PCOS frequently report sleep disturbances (Shreeve *et al.*, 2013). However, these samples comprise women with more severe presentations of PCOS (Ezeh *et al.*, 2013) and are usually compared with a convenience sample of controls, limiting generalizability of the findings. Obesity, which is common in women with PCOS (Barry *et al.*, 2011; Lim *et al.*, 2012), has been considered as a mediator of sleep profiles, but little attention has been given to depression which is also common in women with PCOS (Barry *et al*, 2011; Lim *et al*, 2012) and is associated with sleep disturbances in the general population (Bixler *et al.*, 2005). The degree to which these potentially modifiable factors jointly account for sleep disturbances in women with PCOS is unknown.

The aim of this study was to ascertain whether there is an excess of sleep disturbances in women with PCOS in a community-based sample, and to investigate the degree to which this is accounted for by obesity, depressive symptoms or other factors that may be amenable to intervention.

Materials and Methods

Study design and population

Data for this study were obtained from the first wave of data collection for a cohort of women born during 1973–1975 at a large maternity hospital in Adelaide, South Australia. To be eligible to participate in the cohort, the baby must have survived to discharge and, as an adult, be capable of providing socio-demographic and health information. At around age 30 years, 2046 women (93%) were traced, across Australia, and contacted by letter and telephone. Sixty-two women were confirmed to be deceased or severely disabled. Of those remaining eligible, 974 (49%) agreed to participate and provided core information, in a personal interview with a research nurse where possible ($n = 756$), or via telephone ($n = 218$) if they were not geographically close to Adelaide and had no plans to visit. The sample analysed here comprises women interviewed in person in Adelaide, who provided core information, completed additional questionnaires and had anthropometric measurements made by a research nurse (Fig. 1). After excluding the 32

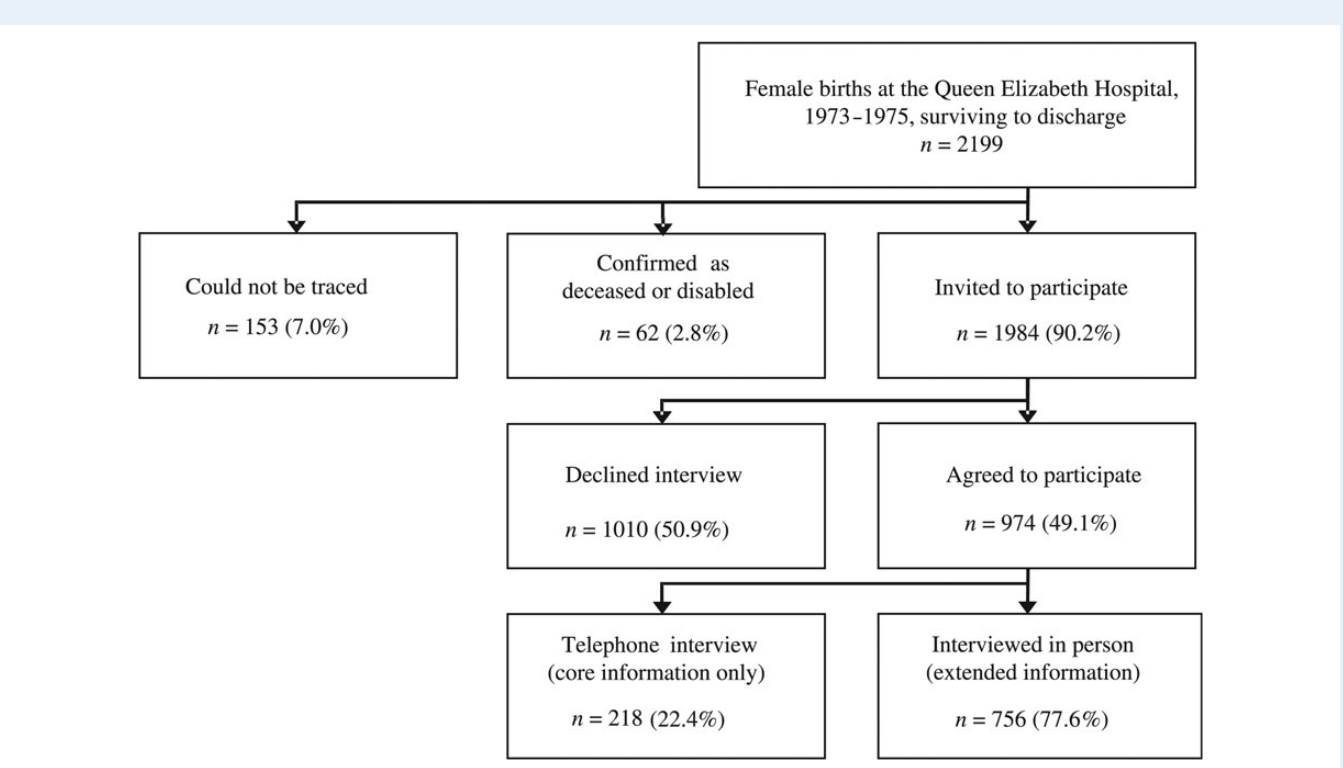

Figure 1 Flow diagram for cohort tracing and participation.

individuals with missing information on one or more key variables, the sample available for analysis comprised 724 women.

Interviews, following a structured pro-forma, were conducted by trained research nurses, usually in the home of the participant. Anthropometric measurements were made in duplicate with the mean calculated and used in analyses. Weight was measured using digital scales and height was measured using a portable stadiometer, following World Health Organization protocols (WHO, 1995). Full details of the methods have been reported previously (March et al., 2010). The study was approved by the relevant hospital and the University ethics committees, and all participants gave informed written consent. At birth, cohort members were broadly representative of all female babies born at the hospital in the relevant period and eligible to join the cohort but, on average, their families had slightly higher socio-economic status.

PCOS classification

PCOS, based on the Rotterdam consensus criteria (The Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group, 2004), was identified by the presence of at least two of the following three symptoms: menstrual disorders; clinical and/or biochemical hyperandrogenism; polycystic ovaries.

Menstrual dysfunction was assessed as the presence of chronic amenorrhea, or a usual cycle length of <21 days or >35 days, or more than a 4-day variation between cycles. Where circumstances existed that disrupted a woman's natural menstrual cycle, such as hormonal contraception, pregnancy or hysterectomy, she was asked to report her former, usual menstrual cycle. The modified Ferriman–Gallway method was used to assess hirsutism. Following the interview, women were invited to provide a fasting blood sample for biochemical analysis. Hyperandrogenism was based on a Ferriman–Gallway score of at least 8 or results of biochemical analysis. Women with either menstrual dysfunction or hyperandrogenism were referred to a reproductive medicine clinic for a transvaginal ultrasound, and 108 underwent this procedure, with appointments scheduled at a time convenient for the participant, up to 12 months following the interview.

Sleep disturbances

Each woman reported her global perception of herself as a 'good' or 'poor' sleeper, or 'neither'. A modified version of the Jenkins Sleep Questionnaire (Jenkins et al., 1988), which characterizes sleep disturbances across a typical week, was then completed. Each woman reported: (a) how commonly she had difficulty falling asleep at night (never, rarely, occasionally, often, almost always); (b) how many nights her sleep was interrupted by awakening (never or 1, 2–3, 4–5, 6–7 nights); if she woke she was asked the reason why and how much time, on average, she took to resume sleep; (c) how many days of the week she woke up before intending to and could not get back to sleep (never or 1, 2–3, 4–5, 6–7 days); (d) how commonly she felt day time drowsiness (never, rarely, etc.); and (e) how commonly she felt moody or irritable because of poor sleep (never, rarely, etc.).

Where a woman reported in (b) that she woke at night to attend to children but had no difficulty resuming sleep, this was not considered a conventional sleep disturbance. Where a woman reported no reason for waking in (b), and took more than 15 min to resume sleep, she was classified as having difficulty maintaining sleep for the relevant number of nights.

Other variables

Obesity, depression, high alcohol consumption, smoking, lack of physical activity and type 2 diabetes were identified in the literature as influences on sleep disturbances (Owens and Matthews, 1998). BMI was calculated as weight (kg) divided by the square of height (m^2), with weight and height measured using standard protocols; women were classified as overweight or obese using cut-offs of 25 and 30 kg/m^2, respectively. Depressive symptomatology was assessed using the Centre for Epidemiological Studies Depression Scale (CES-D) for which a score of more than 16 indicates the presence of symptoms of clinical depression (Radloff, 1977; Weissman et al., 1977). Information on alcohol consumption, smoking, physical activity and type 2 diabetes was obtained using validated questions drawn from national surveys of cardiovascular risk factors (Bennett and Magnus, 1994).

Statistical analysis

Comparisons between the analysis sample (interviewed in person and clinically assessed) and the remainder of the cohort (core information obtained via telephone) were made using Chi-square tests of association, independent samples *t*-tests or the Mann–Whitney *U*-test, as appropriate for categorical, normally distributed or skewed continuous variables, respectively. These same tests were used to make initial comparisons between women with and without PCOS in the analysis sample.

Ordered logistic regression was used to quantify associations between PCOS status and each type of sleep disturbance, taking into account other factors that are potentially influential. This approach was necessary because sleep disturbances were characterized on scales that were ordinal but not necessarily interval. The assumption of proportional odds was examined for each model; that is, whether it was reasonable to assume that the coefficients describing the relationship between PCOS and the lowest category of sleep disturbance frequency (e.g. 'never') versus all higher categories were the same as those that describe the relationship between the two lowest (e.g. 'never' and 'rarely') and all higher etc. All but one model clearly met this assumption, and the one exception (Model 3 for waking for no reason) was borderline, so generalized ordered logistic models were not warranted. Odds ratios (OR) (with 95% confidence intervals) were produced for each model.

Each of the five 'lifestyle' influences on sleep disturbances identified in the literature could be on the causal pathway linking PCOS and sleep disturbances, and were thus considered as potential mediators rather than as potential confounding variables. The presence of a partner or children met the classical definition of potential confounders, so were considered as such. Only five women had a diagnosis of type 2 diabetes, so this variable was not considered further.

Mediating and confounding variables were considered individually, then in a model including all lifestyle influences and finally in a model considering family factors. Variables were retained if $P < 0.1$ and the OR for the association between PCOS and the specific sleep outcome changed by more than 10%. Statistical analyses were carried out in Stata version 11.2 (StataCorp LP, College Station, TX, USA).

Results

Among the sample of 724 women, around one-third had not completed high school. At age 30 years, 466 (64%) lived with a partner (defacto or married) and 402 (56%) had at least one child. In all, 87 (12%) met the Rotterdam criteria for PCOS.

Compared with cohort members who were not included in the analysis sample ($n = 250$), included women ($n = 724$) were slightly younger (mean age 30.4 versus 31.8 years; $P < 0.01$) and less likely to have children (55 versus 67%; $P < 0.01$). However, the two groups were not significantly different in terms of smoking status, physical activity patterns, partnering and educational attainment.

For the analysis sample, comparisons between those with and without PCOS are presented in Table I. As expected, statistically significant differences between the groups occurred in relation to body size and clinical symptoms of depression, observed among half of those with PCOS compared with less than a third of those without PCOS. Partnering was also

Table I Characteristics of women with and without polycystic ovary syndrome (PCOS).

Characteristics	PCOS present $n = 87$ median (IQR) or n (%)	Non PCOS $n = 637$ median (IQR) or n (%)	P-value
Age (yrs)	30.2 (29.9–30.8)	30.2 (29.9–30.9)	0.90
Height (cm)	163 (160–169)	164 (159–168)	0.48
Weight (kg)	80 (68–105)	68 (60–81)	<0.001
BMI (kg/m^2)	30.1 (25.1–38.6)	25.4 (22.4–29.9)	<0.001
Depressive symptoms (CES-D>16)	43 (49.4)	192 (30.1)	<0.001
Alcohol (standard drinks/day)			0.051
0	18 (20.7)	94 (14.9)	
1–2	25 (28.7)	265 (41.9)	
>2	44 (50.6)	274 (43.3)	
Current smoker	28 (32.2)	178 (27.9)	0.41
Physical activity			0.42
None	21 (24.1)	167 (26.2)	
Regular less vigorous	42 (48.3)	261 (41.0)	
Regular vigorous	24 (27.6)	209 (32.8)	
Living with a partner	47 (54.0)	419 (65.8)	0.03
At least one child	46 (52.9)	356 (55.9)	0.60
Educational attainment			0.35
Some high school	31 (35.6)	180 (28.3)	
Completed high school	34 (39.1)	287 (45.1)	
Tertiary	22 (25.3)	170 (26.7)	
Type 2 diabetes	1 (1.5)	4 (0.6)	0.47
Thyroid condition	4 (4.6)	22 (3.5)	0.57
Asthma	22 (25.3)	166 (26.0)	0.88
Pregnant	2 (2.3)	19 (3.0)	0.72

CES-D, Centre for Epidemiological Studies Depression Scale, Student's t-test or Mann-Whitney U for continuous variables, Chi-square test for categorical variables.

statistically significant, although it is notable that over half of those with PCOS were married or in a defacto relationship. Alcohol consumption above the daily recommended limit for women was somewhat more common in those with PCOS than those without (borderline statistical significance). The groups were not statistically different in terms of a number of other health conditions that could affect sleep (Table I).

Sleep profiles are presented in Table II. Almost three-quarters of women reported themselves to be 'good' or 'neither good nor poor' sleepers. Consistent with this, the majority of women reported: at most 'occasionally' having difficulty falling asleep at night (78%); never waking up for no reason, then remaining awake for more than a short time (85%); and being unaffected by waking early (57%). The majority of women at most 'occasionally' experienced daytime drowsiness (59%) or moodiness/irritability due to poor sleep (78%).

The profiles for women with and without PCOS were markedly different in two respects: 35% of those with PCOS 'often' or 'almost always' had difficulty falling asleep compared with 20% of those without PCOS; and 21% of those with PCOS awoke for no reason and did not resume sleep reasonably quickly (in ≤15 min) on two or more nights per week, compared with 11% of their counterparts. These differences were statistically significant.

In logistic regression, a diagnosis of PCOS was positively associated with overall self-perception of being a 'poor' sleeper (an increase of almost 70% in the odds compared with the experience of those without PCOS). This association reflected the greater tendency to high BMI and/or depressive symptoms in women with PCOS, becoming weaker and no longer statistically significant when either factor was added to the model (Table III).

More specifically, as shown in Table III, women with PCOS had around twice the odds of increased difficulty falling asleep, compared with the experience of those without PCOS (i.e. twice as likely to be in any set of worse categories for a given set of reference categories, e.g. at most 'occasionally' versus 'often' or 'almost always'). The effect size was attenuated slightly when BMI was taken into account, and to a greater degree by depressive symptoms, but a statistically significant increase (of around 50% elevated odds) persisted after both factors were included in the model. A diagnosis of PCOS was associated with increased waking for no reason and not being able to resume sleep reasonably quickly (around double the odds), with the size of the OR reduced only slightly when the BMI category was considered, more strongly attenuated when depressive symptoms were taken into account and no longer statistically significant when both factors were included in the model.

Table II Sleep disturbances for women with and without PCOS.

	PCOS present *n* = 87 *n* (%)	Not PCOS *n* = 637 *n* (%)	Total *n* = 724 *n* (%)	*P*-value
Type of sleeper				
Good sleeper	41 (47.1)	334 (52.4)	375 (51.8)	0.12
Neither good nor poor	19 (21.8)	167 (26.2)	186 (25.7)	
Poor sleeper	27 (31.0)	136 (21.4)	163 (22.5)	
Difficulty falling asleep				
Never	12 (13.8)	110 (17.3)	122 (16.9)	<0.01
Rarely	16 (18.4)	184 (28.9)	200 (27.6)	
Occasionally	29 (33.3)	213 (33.4)	242 (33.4)	
Often	14 (16.1)	86 (13.5)	100 (13.8)	
Almost always	16 (18.4)	44 (6.9)	60 (8.3)	
Wakes at night for no reason and cannot resume sleep within 15 min				
Never	67 (77.0)	551 (86.5)	618 (85.4)	0.02
1 night	2 (2.3)	13 (2.0)	15 (2.1)	
2–3 nights	7 (8.1)	20 (3.1)	27 (3.7)	
4–5 nights	1 (1.2)	19 (3.0)	20 (2.8)	
6–7 nights	10 (11.5)	34 (5.3)	44 (6.1)	
Wakes before intended in the morning				
Never	42 (48.3)	373 (58.6)	415 (57.3)	0.28
1 night	17 (19.5)	79 (12.4)	96 (13.3)	
2–3 nights	17 (19.5)	116 (18.2)	133 (18.4)	
4–5 nights	4 (4.6)	19 (3.0)	23 (3.2)	
6–7 nights	7 (8.1)	50 (7.9)	57 (7.9)	
Drowsy in daytime				
Never	10 (11.5)	66 (10.4)	76 (10.5)	0.52
Rarely	13 (14.9)	95 (14.9)	108 (14.9)	
Occasionally	22 (25.3)	218 (34.2)	240 (33.2)	
Often	23 (26.4)	149 (23.4)	172 (23.8)	
Almost always	19 (21.8)	109 (17.1)	128 (17.7)	
Moody or irritable because of poor sleep				
Never	9 (10.3)	114 (17.9)	123 (17.0)	0.18
Rarely	23 (26.4)	180 (28.3)	203 (28.0)	
Occasionally	28 (32.2)	209 (32.8)	237 (32.7)	
Often	20 (23.0)	95 (14.9)	115 (15.9)	
Almost always	7 (8.1)	39 (6.1)	46 (6.4)	

The Chi-square test.

PCOS was not associated with early awakening or daytime drowsiness in any of the fitted models. An association between PCOS and irritability/moodiness due to poor sleep was statistically significant, but not after the inclusion of BMI and/or depressive symptoms.

None of the other lifestyle variables affected the associations between PCOS and sleep outcomes. Presence of a partner and/or children did not confound any association after lifestyle factors were considered. Thus, none of these variables are included in the models presented in Table III.

Discussion

We report here, for the first time, an investigation of sleep disturbances in a community-based sample of women with and without PCOS. Over one-third of women with PCOS frequently had difficulty falling asleep, and one in five frequently awoke for no reason and could not resume sleep within a short time period. For each type of disturbance, this approached twice the prevalence found among women of the same age without PCOS.

The greater occurrence of overweight and obesity in women with PCOS had a minimal role in their difficulty falling asleep, whereas symptoms of clinical depression more strongly mediated this association. Nevertheless, even when both BMI and depressive symptoms were taken into account, women with PCOS were still more likely to experience difficulty achieving sleep compared with their counterparts. Difficulty maintaining sleep among women with PCOS was minimally explained by their body size and, to a greater extent, depressive symptoms. Together, these factors fully mediated the association, but this does not mean that there is no role for PCOS.

The two groups of women had similar experiences of unintended early awakening and daytime drowsiness. However, women with PCOS had an excess of moodiness/irritability due to poor sleep which, as expected in view of the above, was connected with BMI and depressive symptoms. There was no evidence that other determinants of sleep disturbances contributed to the observed associations.

To date, researchers have predominantly focused on OSA in women with PCOS. Our research demonstrates that other forms of sleep disturbance are also common across the continuum of severity of the heterogeneous condition of PCOS. Body size had a relatively minor role as a mediator. In a very large US survey, associations between measures of body size and sleep duration varied with age and were weaker in the presence of co-morbidities, which Ford *et al.* (2014) suggest as the reason for considerable inconsistency in the wider literature on body size and sleep parameters (Ford *et al.*, 2014).

The stronger mediating role for depressive symptoms indicated by our results aligns with a previous study reporting depression-related reduced sleep in women with PCOS (Jedel *et al.*, 2010). In research in the general population, poor mental health often accompanies sleep disturbances or indicators of insufficient sleep (Bixler *et al*, 2005) or OSA (Peppard *et al.*, 2006) although not consistently (DeZee *et al.*, 2006; Asghari *et al.*, 2012). This relationship appears to be bi-directional, with brain functioning, cognitive performance and mood altered by insufficient or fragmented sleep and vice versa (Naismith *et al.*, 2004; Alvaro *et al.*, 2013). Detection and management of depression in women with PCOS is thus underscored as a potential means to intervene and improve immediate quality of life as well as to maintain long-term cardio-metabolic health through several pathways (Pan *et al.*, 2012; Lai *et al.*, 2013), including preventing sleep-related deterioration of glucose-insulin regulated homeostasis.

Our findings concerning difficulty achieving sleep in women with PCOS point to an underlying issue, possibly with a common aetiology. In a clinical polysomnography study with a primary focus on OSA, longer sleep latency was reported in women with PCOS, suggested as possibly due to the perturbed stress system in women with PCOS (Vgontzas *et al.*, 2001). More generally, women with PCOS have heightened hypothalamic–pituitary–adrenal axis reactivity (Benson *et al.*, 2009), which is linked with sleep disturbances (Vgontzas, 2008). There are also other candidate mechanisms, as the circadian sleep–wake

Table III Associations between PCOS status and six sleep disturbance outcomes, results of ordered logistic regression models.

Sleep characteristic (each considered separately as an outcome variable)	Model A Unadjusted OR (95% CI)	Model B Adjusted for BMI OR (95% CI)	Model C Adjusted for depressive symptoms OR (95% CI)	Model D Adjusted for BMI and depressive symptoms OR (95% CI)
Poor sleeper versus good/neither	1.66 (1.01–2.71)	1.63 (0.98–2.69)	1.55 (0.94–2.56)	1.54 (0.93–2.56)
Difficulty falling asleep	1.94 (1.28–2.95)	1.85 (1.21–2.83)	1.57 (1.03–2.38)	1.54 (1.01–2.36)
Wakes for no reason, for >15 min	1.92 (1.12–3.31)	1.87 (1.07–3.27)	1.74 (1.00–3.02)	1.73 (0.98–3.03)
Unintended early morning waking	1.35 (0.89–2.05)	1.32 (0.87–2.01)	1.17 (0.77–1.78)	1.18 (0.77–1.80)
Drowsy in daytime	1.20 (0.80–1.81)	1.09 (0.72–1.65)	0.95 (0.63–1.43)	0.89 (0.58–1.36)
Moody or irritable because of poor sleep	1.59 (1.06–2.37)	1.43 (0.95–2.15)	1.23 (0.81–1.86)	1.15 (0.75–1.74)

CI, confidence interval; OR, odds ratio.

cycle also involves peripheral regulation through neurotransmitters and neuromodulators, including melatonin and cytokines. Women with PCOS have altered cytokine profiles (Xiong *et al.*, 2011) and elevated day and night urinary levels of the melatonin metabolite 6-sulfatoxymelatonin (Luboshitzky *et al.*, 2001).

Key strengths of this study are the use of a community-based sample of women, which allowed the full spectrum of severity of PCOS symptoms to be considered. In addition, information on a wide range of potential mediating and confounding variables was obtained. On the other hand, we were confined to questionnaire-based assessments of sleep disturbances, as polysomnographic assessment is not feasible on this scale. There is likely to be a degree of under-ascertainment of PCOS as not all women referred for ultrasound were willing to undergo this procedure; however, this would have a conservative influence on the findings presented. Although we have considered the most important factors affecting sleep in women in this age group (Owens and Matthews, 1998), it is possible that the groups differed in terms of social problems contributing to psychological distress, or mental health problems other than depression. We lack information on these factors; however, both psychological distress and mental illness are associated with high alcohol intake and smoking, particularly in women (Lawrence *et al.*, 2009; Choi and Dinitto, 2011; Liang and Chikritzhs, 2011), and we did examine these behaviours. The cross-sectional nature of the study means that the direction of associations is unclear, although bi-directionality for the mediators is likely based on the wider literature.

In conclusion, this study demonstrates that sleep disturbances are almost twice as common in women with PCOS compared with women of similar age without PCOS. Difficulty achieving and maintaining sleep were most problematic. Obesity had a relatively minor role, with depressive symptoms a stronger mediator. This highlights the importance of assessing and managing both sleep and mental health problems in women with PCOS for short- and longer-term health and quality of life.

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Authors' roles

Authors M.J.D. and V.M.M. were the principal investigators of the Lucina cohort. Together with L.M., W.M. and M.W., they formulated the research question reported in the manuscript and directed its implementation. All authors contributed to the statistical analysis plan and W.M. conducted the statistical analyses. All authors contributed to interpretation of analyses, drafting the article and critically revising the important intellectual content of the manuscript. All authors have approved the final version of the manuscript submitted for publication.

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Conflict of interest

None declared.

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